

Photochemical separation of europium from rare-earth mixtures: influence of irradiance

Bart Van den Bogaert, KU Leuven, Department of Chemical Engineering, Celestijnenlaan 200F. Email: Bart.VandenBogaert@cit.kuleuven.be. Phone: +32 16322343.

Tom Van Gerven, KU Leuven, Department of Chemical Engineering, Celestijnenlaan 200F. Email: Tom.VanGerven@cit.kuleuven.be. Phone: +32 16322342.

Koen Binnemans, KU Leuven, Department of Chemistry, Celestijnenlaan 200F. Email: Koen.Binnemans@chem.kuleuven.be. Phone: +32 16327446.

Lio Van Meerbeeck, KU Leuven, Department of Chemical Engineering, Celestijnenlaan 200F. Email: Lio.VanMeerbeeck@student.kuleuven.be.

ABSTRACT

The rare-earth elements (REEs) are known for their difficult separation, due to their similar physical and chemical properties. Conventional techniques separate REEs into pure fractions by using many stages of low-selective methods. In contrast, innovative process intensification techniques such as selective photochemical reduction yield high purities in a one-step reaction. Currently, photochemical separation is investigated for the recovery of europium and yttrium from the red phosphor in end-of-life compact fluorescent lamps. Due to the high selectivity, this method could also show potential in the pre-processing steps of rare-earth ores, by removing all traces of europium prior to further separation steps.

Photochemical separation of europium from rare earth mixtures is based on the unique redox properties of europium: it is the only REE with a stable divalent oxidation state in aqueous solutions. Therefore, a selective reduction technique alters the properties of only europium by changing its oxidation state, and subsequent separation yields high-purity europium in a single step. Previously, chemical parameters such as pH, rare-earth concentrations and type and concentration of additives have been optimized.¹ The objective of current study was to investigate the influence of the light source used for the photochemical separation, more precisely the influence of irradiance on the illumination time. Irradiance is a measure for the light power, expressed in Watts per unit of area (typically $\mu\text{W}/\text{cm}^2$). It is seen that higher irradiances cause faster europium removal from rare-earth mixtures, by reducing the induction time prior to the actual separation, and by increasing the removal rate once the reaction has started. A threshold value of the irradiance is found, at $2000 \mu\text{W}/\text{cm}^2$, which is the minimum irradiance required for europium removal within a reasonable timeframe. This parameter can be used to assess which light sources are best suited for the construction of a photoreactor for europium separation.

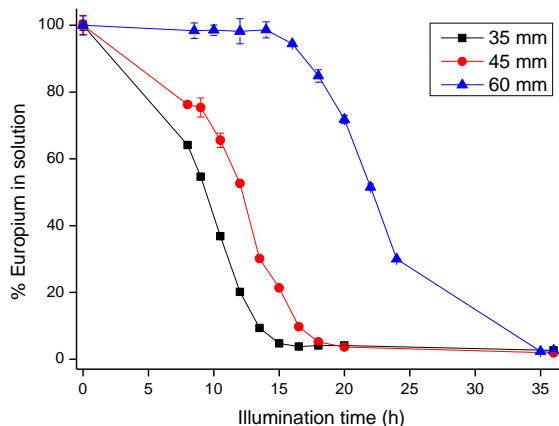


Figure 1. Europium removal at different distances between a 160 W low-pressure mercury lamp and a 10 mM $\text{EuCl}_3 \cdot 6\text{H}_2\text{O}$ solution in HCl pH 4. Shorter distance to the lamp equals higher irradiance and hence faster removal of europium (preliminary results).

KEYWORDS

separation of rare earths, photochemical reduction, europium, yttrium, irradiance, process intensification

1 B. Van den Bogaert, D. Havaux, K. Binnemans and T. Van Gerven, *Green Chem.*, 2015, **17**, 2180–2187.
